Maryland Department of Natural Resources

Understanding Sediment Budgets

…in the context of Watershed Management Strategies

Presentation to the
US Army Corps of Engineers
Economic and Environmental Analysis Conference

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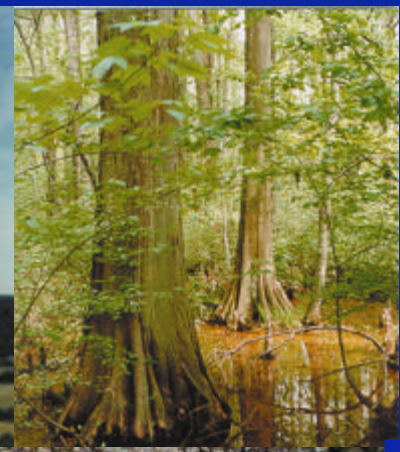
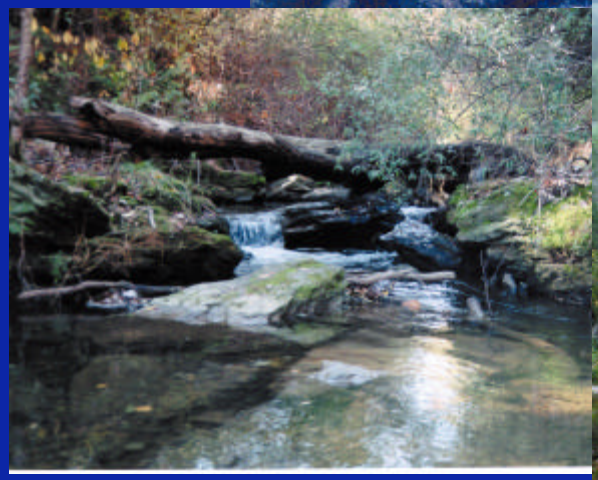
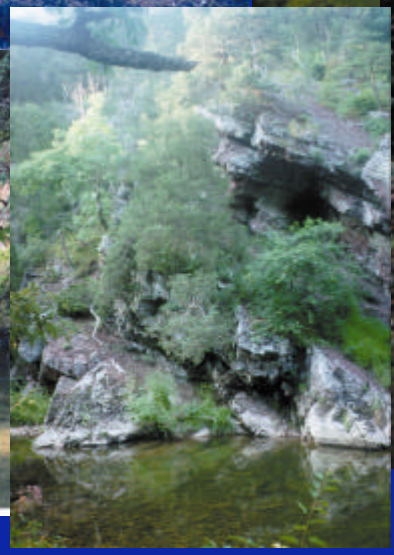
July 17, 2002

(Note that the indicated web links are “active”)

Watershed Restoration Division
Chesapeake and Coastal Watershed Services

Landscape Settings in Maryland



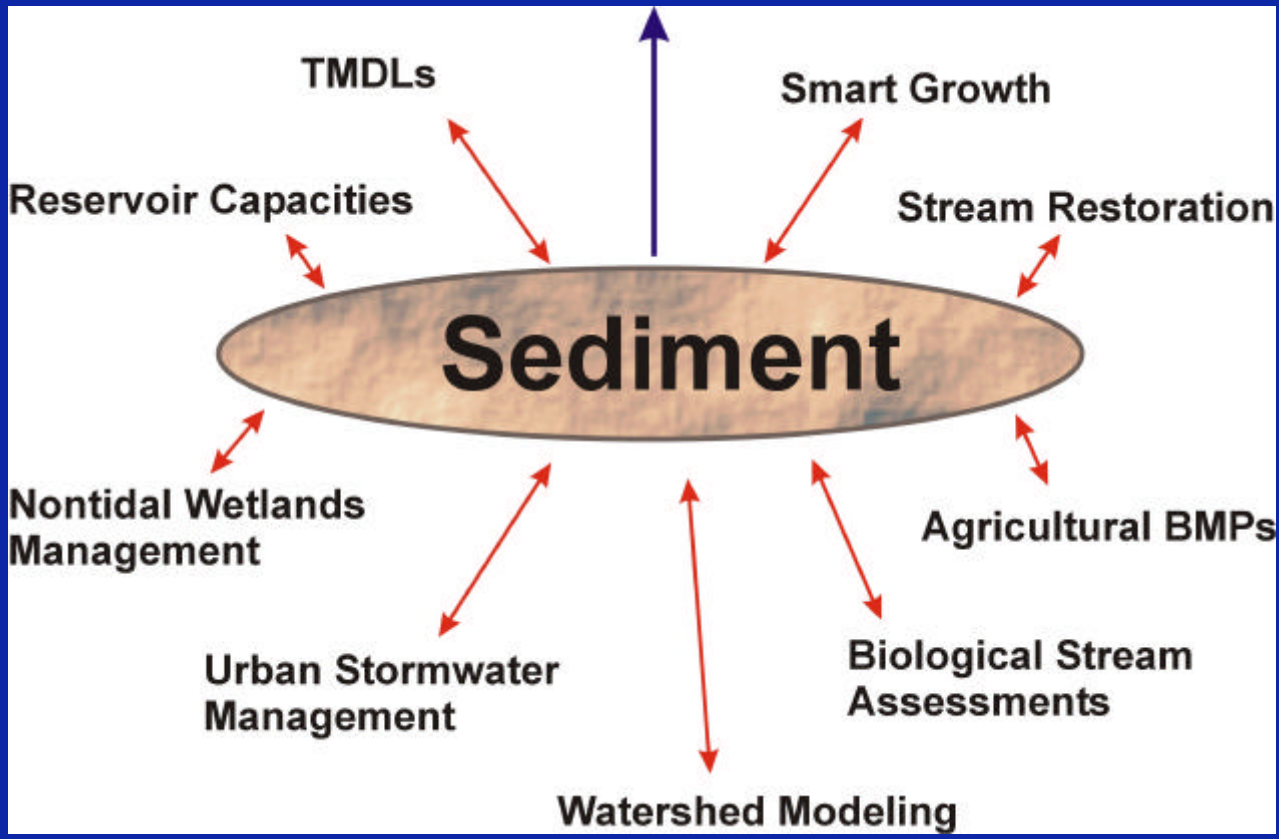





Source: Smith, S. 2000. Streams of Maryland, take a closer look. http://dnrweb.dnr.state.md.us/download/bays/streams/md_streams_wrd.pdf

Chesapeake and Coastal Watershed Services
Watershed Restoration Division

Sediment in the Landscape

Watershed Management Demands



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Sediment Provisions in the 2000 Chesapeake Bay Agreement

Goal: Achieve and maintain the water quality necessary to support the aquatic living resources of the Bay and it's tributaries and to protect human health.

Goal: Preserve, protect, and restore those habitats and natural areas that are vital to the survival and diversity of the living resources of the Bay and it's rivers

Sediment Workgroup of the EPA Chesapeake Bay Program
http://www.chesapeakebay.net/sedwg.htm

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Chesapeake and Coastal Watershed Services

What is sediment management?

1. What are we managing? → 1. **Perspective:** geologic byproduct vs. ag. base vs. pollutant
2. At what scale have we managed sediment? → 2. **Sediment flux:** particle vs. site/reach vs. watershed scales
3. What are the implications of sediment movement? → 3. **Environment:** tidal vs. nontidal

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What is sediment management?

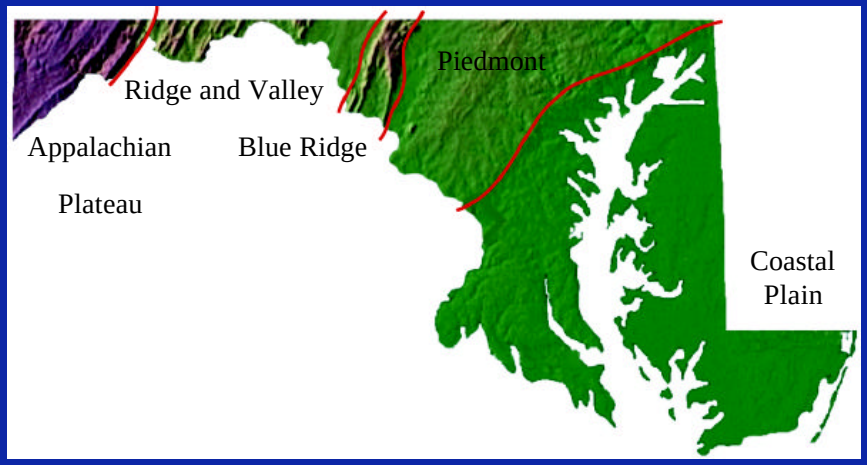
4. How have we managed sediment? → 4. **Approach:** monitoring vs. modeling; active vs. passive control

5. What are the gaps in our understanding and capabilities? → 5. **Reacting vs. predicting:**
   - C2K Commitments
   - TMDLs
   - Regulatory programs

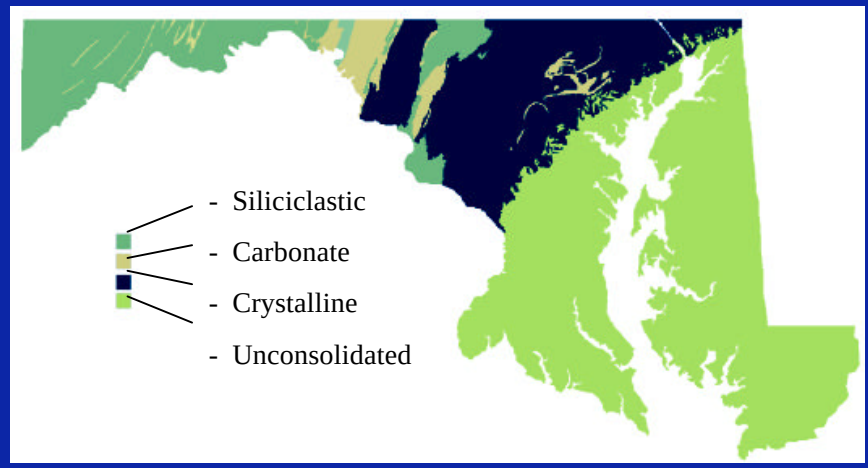
What are we managing?

1. Geologic Byproduct, vs. Agricultural Base, vs. Pollutant

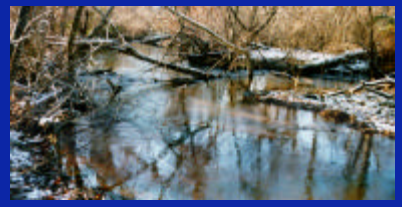
- **Physiography**

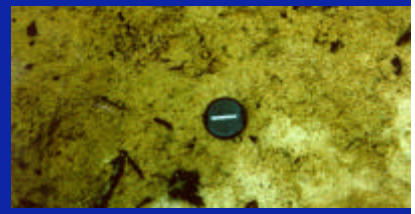


- **Lithology**



Source: Smith, S.. 2000. Streams of Maryland, take a closer look, http://dnrweb.dnr.state.md.us/download/bays/streams/md_streams_wrd.pdf

Chesapeake and Coastal Watershed Services
Watershed Restoration Division

1. Geologic Byproduct, Agricultural Base, vs. Pollutant

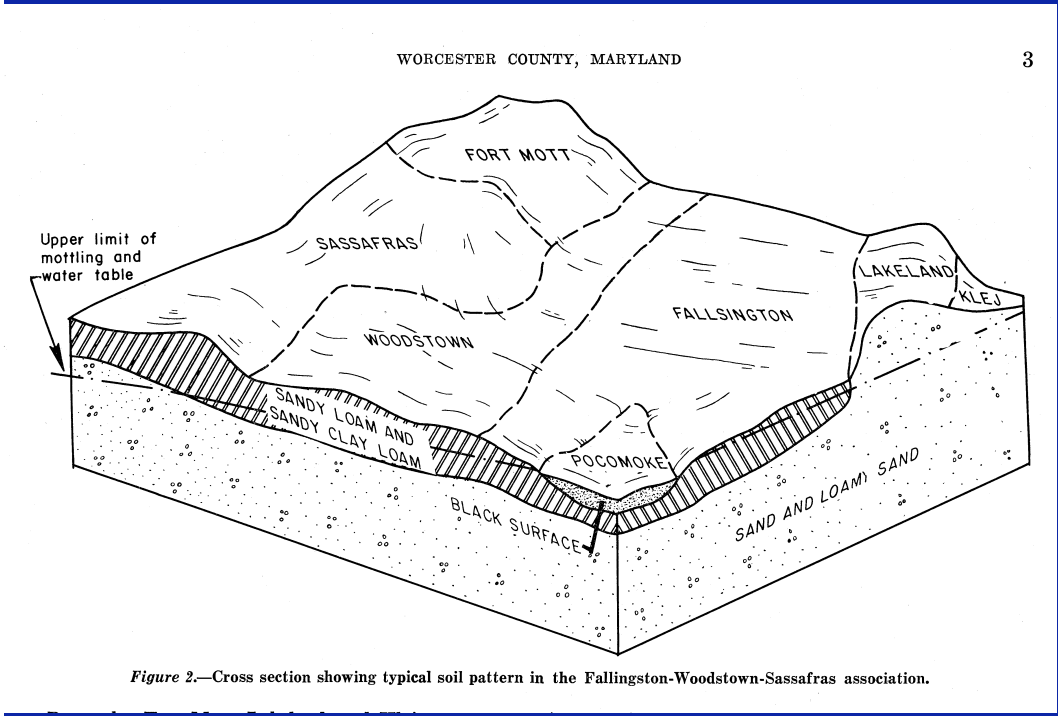


Figure 2.—Cross section showing typical soil pattern in the Fallingston-Woodstown-Sassafras association.

Source: USDA Soil Survey for Worchester County, MD.
Updated version available at: http://www.statlab.iastate.edu/soils/soildiv/

- **Soil surveys**
- **Soil conservation**

Source: Monitoring and Nontidal Assessment Division, Maryland DNR

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1. Geologic Byproduct, Agricultural Base, vs. Pollutant

- **Construction sediment**
- **Dredging**
- **Turbidity**

Construction disturbance
Source: Watershed Restoration Division, Md DNR

Silt fencing
Source: EPA Bay Program

Agricultural drainage ditches on Maryland's Eastern Shore are periodically dredged to remove accumulated sediment.
Source: Watershed Restoration Division, Md DNR
http://www.dnr.state.md.us/bay/tribstrat/final_pd_report.pdf

Sediment trapped during a typical summer rainfall event in Maryland's Piedmont
Source: Watershed Restoration Division, Md DNR

Chesapeake and Coastal Watershed Services
Watershed Restoration Division

2. Where are we managing it?

- **Particle Scale: detachment, suspended load, bedload**
- Site / Reach Scale
- Watershed Scale

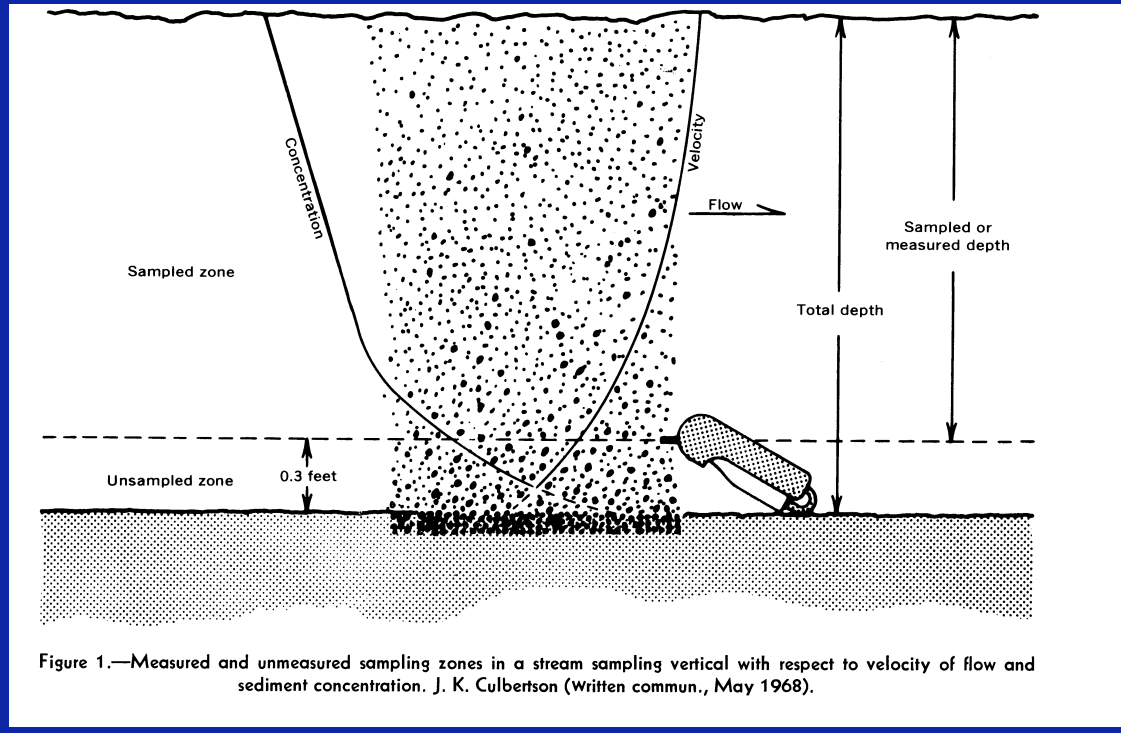

Figure 1.—Measured and unmeasured sampling zones in a stream sampling vertical with respect to velocity of flow and sediment concentration. J. K. Culbertson (written commun., May 1968).

Source: Edwards, T.K. and G.D. Glysson. 1988. Field methods for measurement of fluvial sediment. USGS Rpt. 86-531.

2. At what scale?

- Particle Scale: bedload, suspended load
- **Site / Reach Scale**
- Watershed Scale

Upland agricultural field erosion
Source: Monitoring and Nontidal Assessment Division, Md DNR

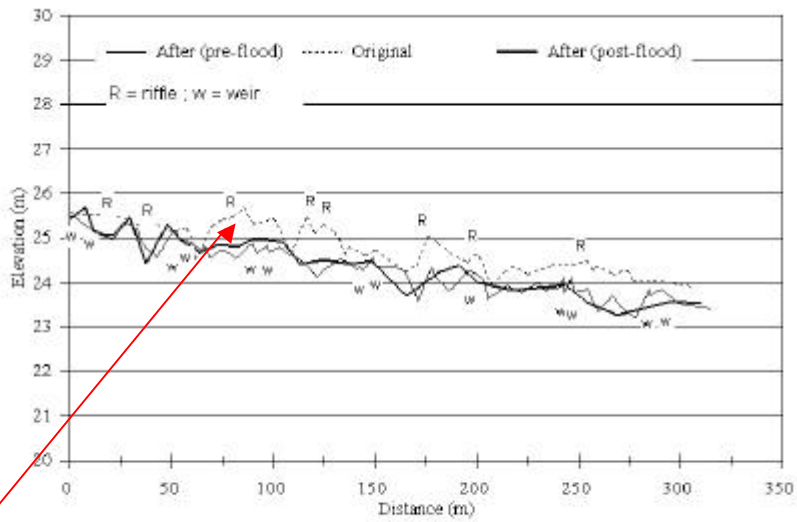

Figure 3: Longitudinal profile before / after construcion / after construction (post-flood)

Longitudinal profile of the reach of Deep Run shown in the picture at right (before, during, after manipulation of the channel). Arrow points to gravel mounds that commonly appear in this geomorphic transition area.
Source: Smith, S. and K. Prestegaard, Dept. of Geology, Univ. of Maryland.

Deep Run at the Howard/Anne Arundel County border in Maryland; Source: Watershed Restoration Division, Md DNR

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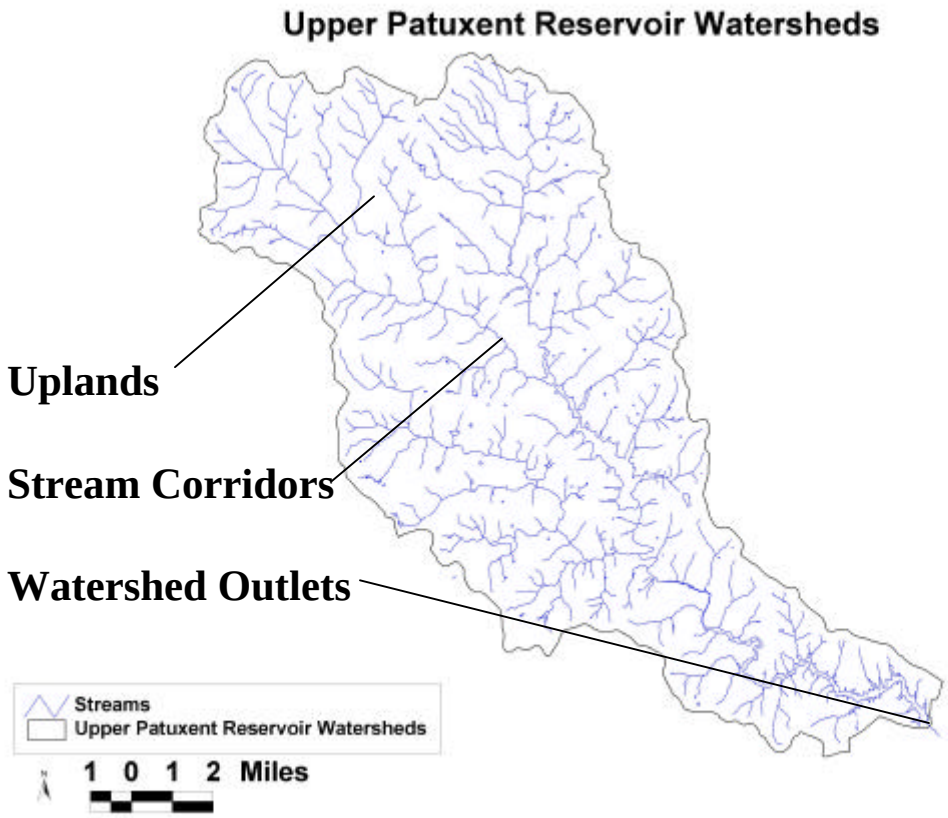
Watershed Restoration Division

2. At what scale?



- Particle Scale: bedload, suspended load
- Site / Reach Scale
- **Watershed Scale**

Source: Watershed Restoration Division, Md DNR

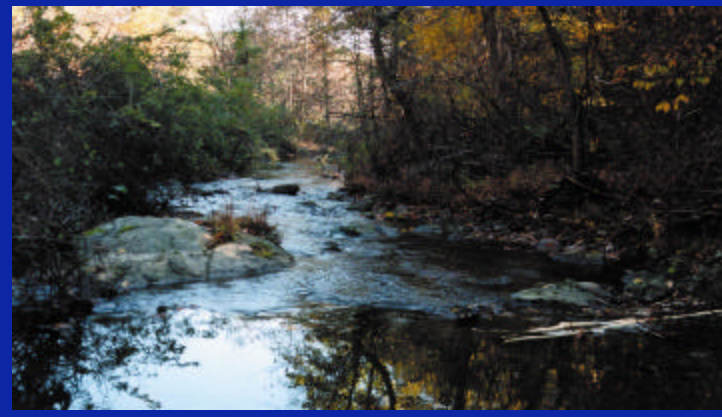
2. At what scale?

Watershed Scale – drainage network process zones

Source Areas

Sinks

Transfer Areas



Source: Smith, S., L. Gutierrez, and A. Gagnon. 2000. Streams of Maryland, take a closer look. http://dnrweb.dnr.state.md.us/download/bays/streams/md_streams_wrd.pdf

2. At what scale?

Watershed Scale – Storage

How old are these sediment deposits?

Mine Bank Run in Baltimore County, Maryland
Source: Monitoring and Nontidal Assessment Division, Maryland DNR

"Legacy" Sediment

Jacobsen, R. and D. Coleman. 1986. Stratigraphy and recent evolution of Maryland Piedmont floodplains. Am. J. of Sci., Vol 286, pp. 617-637.

Allmendinger, N. and J.E. Pizzuto. 2000. Sediment production in an urbanizing watershed. Department of Geology, University of Delaware.

Trimble, S. W.. 1999. Decreased rates of alluvial sediment storage in the Coon Creek Basin, Wisconsin, 1975-93. Science, Vol. 285, pp. 1244-1246.

2. At what scale?

Watershed Scale – yield to tidal tributaries and the Chesapeake Bay

Source: EPA Chesapeake Bay Program

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Watershed Restoration Division

3. Implications of sediment movement

Nontidal ← **Physical Stability** → **Tidal**

Mine Bank Run (Source: Md DNR, Monitoring and Nontidal Assessment Division)

Deep Run
(Source: Smith, S. and K. Prestegaard, Dept. of Geology, Univ. of Maryland)

Deep Run (Source: Smith, S. and K. Prestegaard, Dept. of Geology, Univ. of Maryland)

Calvert Cliffs (Source: Md Geol. Survey)

Calvert Cliffs (Source: Md Geol. Survey)

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3. Implications of sediment movement

Nontidal ← **Habitat** → **Tidal**

Clean gravel and embedded stream bottom conditions (above)
Source: Md DNR, Monitoring and Nontidal Assessment Division

Tidal Submerged Aquatic Vegetation (above) and blue crab (below)

Brook Trout
Source: R. Bachman, Md DNR

Source: EPA Chesapeake Bay Program
http://www.chesapeakebay.net

EPA Chesapeake Bay Program Water Clarity Goals

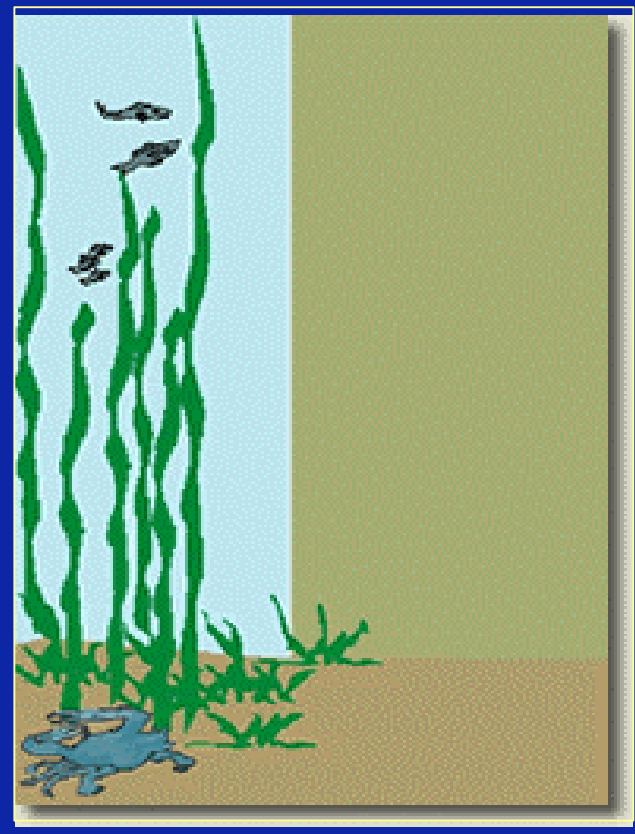
Good Water Clarity

Percent of sunlight reaching leaves:

- **13% in low salinity waters**
- **22% in high salinity waters**

Poor Water Clarity

- **Sediment and other particles in the water**
- **Algae in the water**
- **Algae on the leaves**



Source: EPA Chesapeake Bay Program
Water Clarify Criteria Available at
http://www.chesapeakebay.net/wqcdefiningtech.htm

Low % of sunlight reaching leaves = Bay grasses grow poorly or die

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4. How have we managed sediment?

Stream Gaging

Sediment Monitoring

Source: Watershed Restoration Division, Md DNR

Source: Md Geological Survey
http://www.mgs.md.gov

Geomorphic Mapping

Watershed Restoration Division
Chesapeake and Coastal Watershed Services

4. How have we managed sediment?

Sediment Sampling

- **Bedload load ???**
- **Suspended load**
  (TSS vs Suspended Sediment)

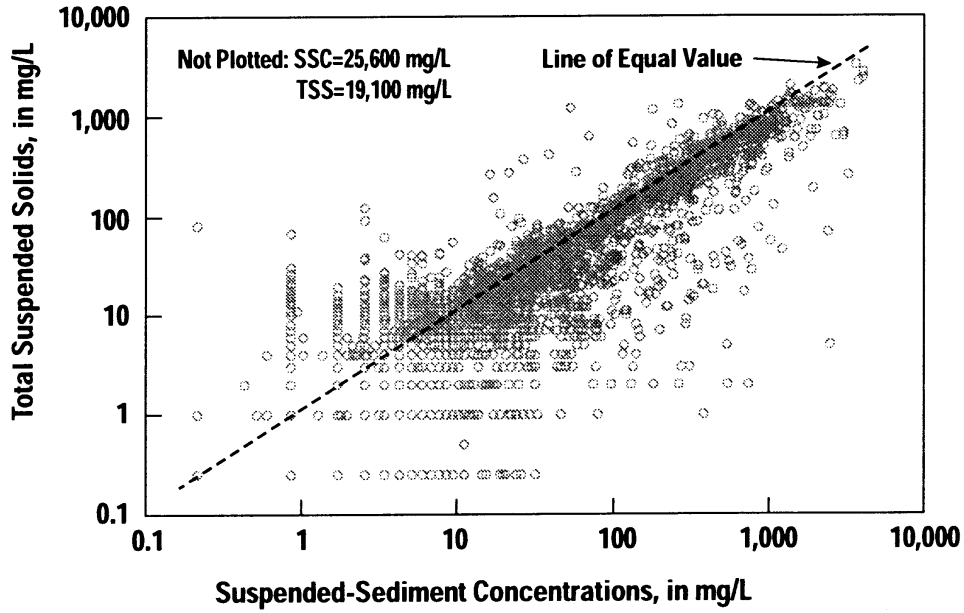
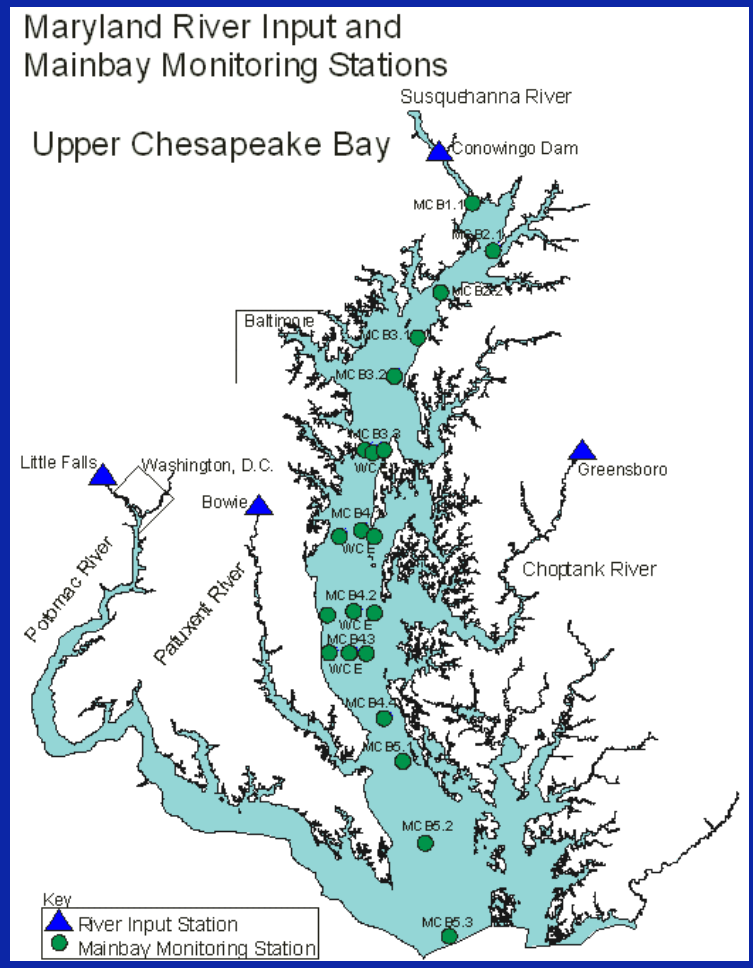


Figure 3. Relation between the base-10 logarithms of suspended-sediment concentration (SSC) and total suspended solids (TSS) for 3,235 data pairs in the scattergrams plotted. All SSC and TSS values less than 0.25 mg/L were set equal to 0.25 mg/L to enable plotting the data on logarithmic coordinates.

Source: J. R. Gray, G. D. Glysson, L. M. Turcios, and G. E. Schwarz. 2000. Comparability of suspended-sediment concentration and total suspended solids data. USGS Water-Resources Investigations Report 00-4191 http://water.usgs.gov/osw/pubs/WRIR00-4191.pdf

4. How have we managed sediment?

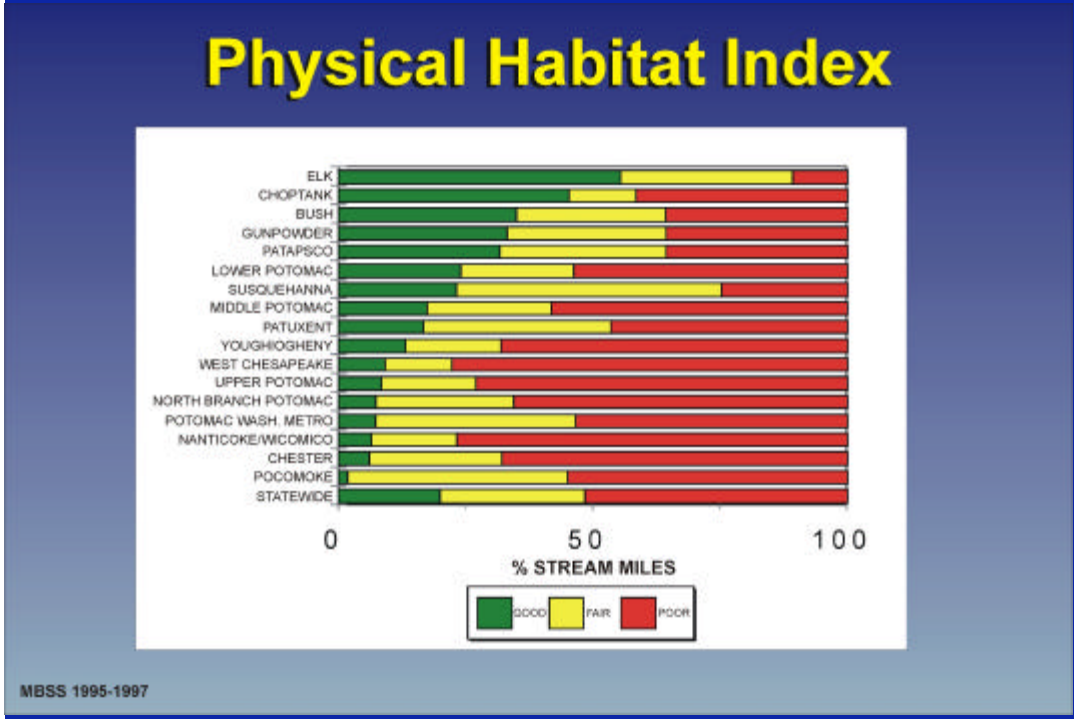


Sediment Monitoring
River Input

River Input Monitoring Stations
Source: Md DNR,
http://www.dnr.state.md.us/bay/monitoring/river/monitoring_stations.html

4. How have we managed sediment?

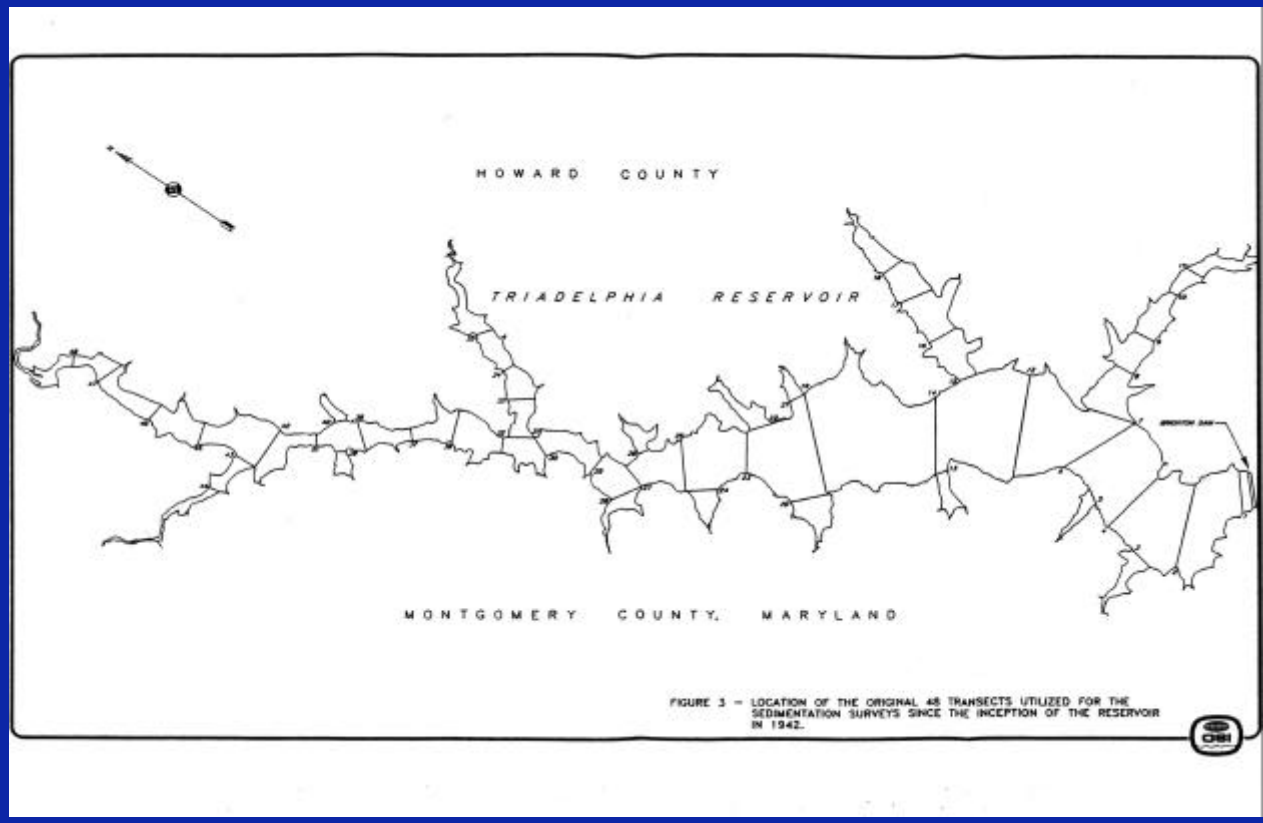
Habitat (Sediment) Assessments



Source: Boward, D., P. Kazyak, S. Stranko, M. Hurd, and A. Prochaska. 1999. From the Mountains to the Sea: The State of Maryland's Freshwater Streams. EPA 903-R-99-023. Maryland Department of Natural Resources, Monitoring and Non-tidal Assessment Division, Annapolis, Maryland. http://www.dnr.state.md.us/streams/pubs/md-streams.pdf

4. How have we managed sediment?

Reservoir Sedimentation

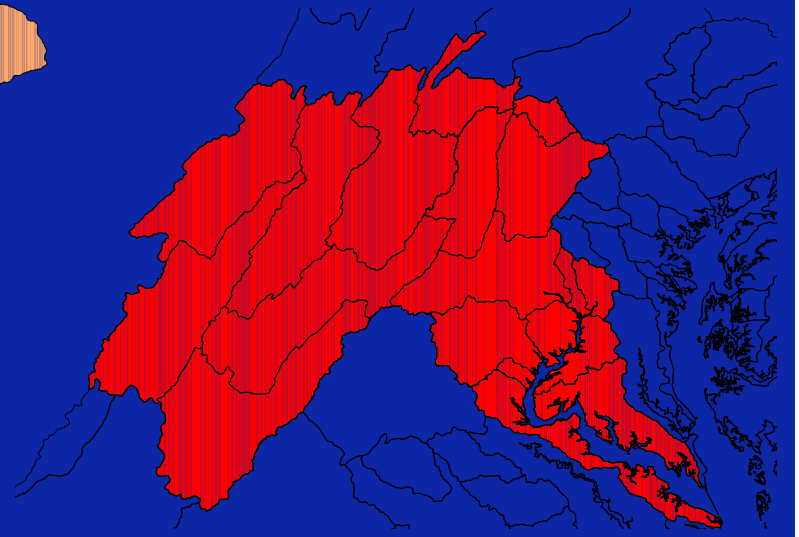


Source: Ocean Surveys, Inc.. (1997) for Washington Suburban Sanitary Commission

4. How have we managed sediment?

Basin Modeling

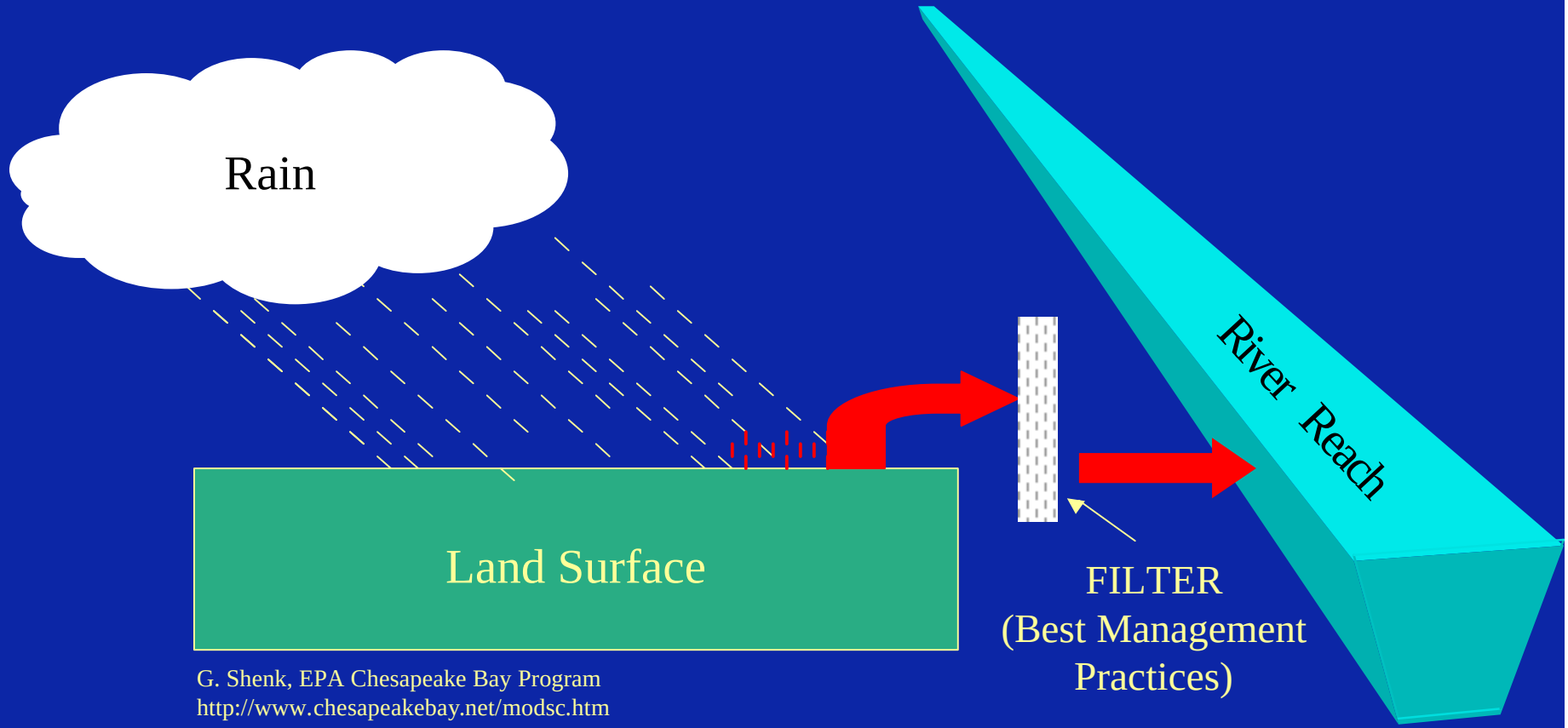
- Deliver loads to the Chesapeake Bay estuarine model
- Determine management impacts



Source: G. Shenk, EPA Chesapeake Bay Program
http://www.chesapeakebay.net/modsc.htm

4. How have we managed sediment?

Basin Modeling



G. Shenk, EPA Chesapeake Bay Program
http://www.chesapeakebay.net/modsc.htm

Chesapeake and Coastal Watershed Services
Watershed Restoration Division

4. How have we managed sediment?

Control - Active Approaches (Nontidal)

Construction Silt Fencing
(Source: EPA Chesapeake Bay Program)

Stormwater Management Pond
(Source: Md DNR, Watershed Restoration Division)

Riprap stabilization
(Source: Md DNR, Watershed Restoration Division)

4. How have we managed sediment?

Active Approaches - Stream Restoration

Trib 9 (Source: Watershed Restoration Division, Md DNR)

Trib 9 Success

Deep Run (Source: Smith, S. and K. Prestegaard, Dept. of Geology, Univ. of Maryland)

Deep Run Problems

Watershed Restoration Division
Chesapeake and Coastal Watershed Services

4. How have we managed it?

Control - Active Approaches (Tidal)

Poplar Island Beneficial Use Site
Source: U.S. Army Corps of Engineers, Baltimore District,
http://www.nab.usace.army.mil/projects/Maryland/poplarisland.htm
http://www.nab.usace.army.mil/projects/Maryland/poplar-brief.htm

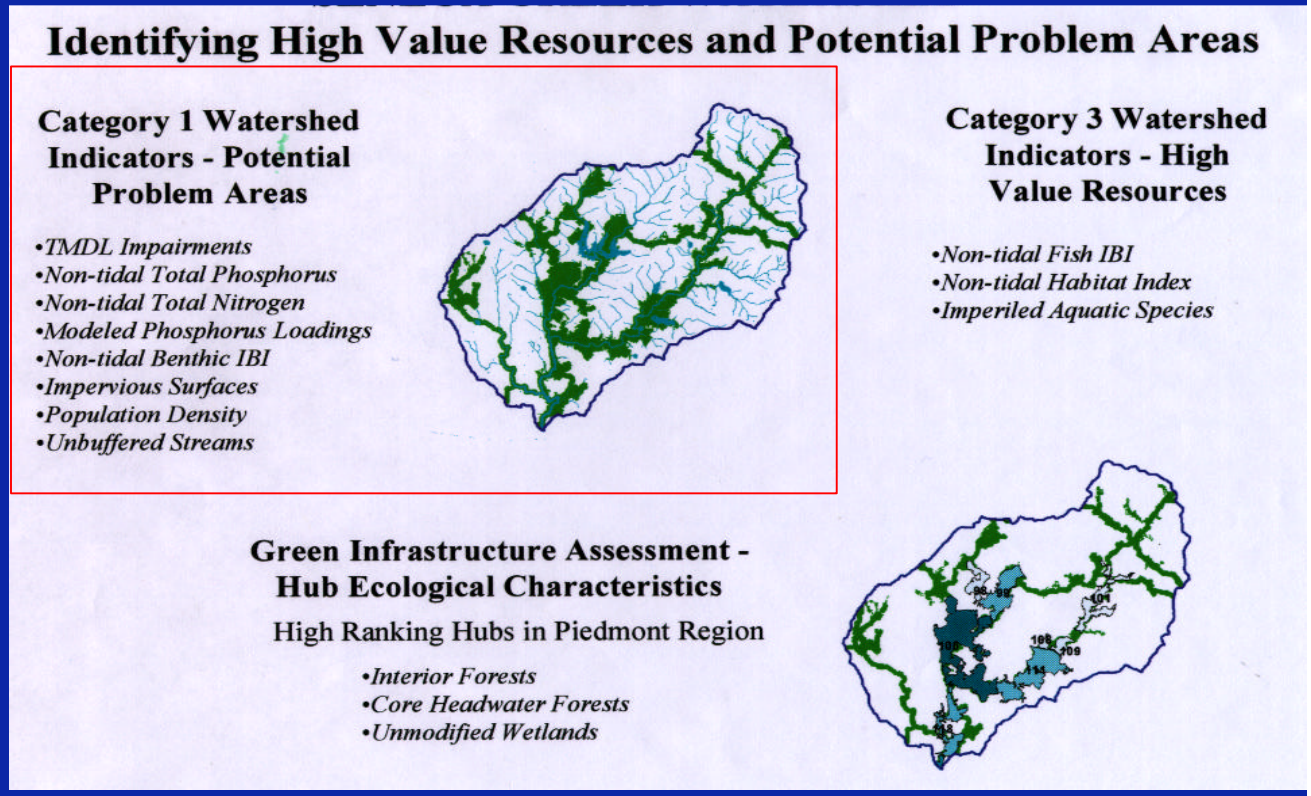
4. How have we managed sediment?

Control: Passive Approaches (Nontidal)

Smart Growth

Watershed Restoration Action Strategies

Adding sediment indices derived from improved monitoring and the development of sediment budgets will advance these planning efforts



Source: Chesapeake and Coastal Watershed Services, Md DNR
http://www.dnr.state.md.us/bay/czm/wras/

5. Gaps in our understanding / capabilities?

- **Limited ability to accurately predict watershed sediment flux at small spatial scales (Tributary Strategy watersheds) and short time scales (decadal and instantaneous)**

- **Connections between watershed sediment process zones (production, transfer and storage zones)**

5. Gaps in our understanding / capabilities?

How is "growth" going to affect watershed sediment movement

…to streams,

…to reservoirs,

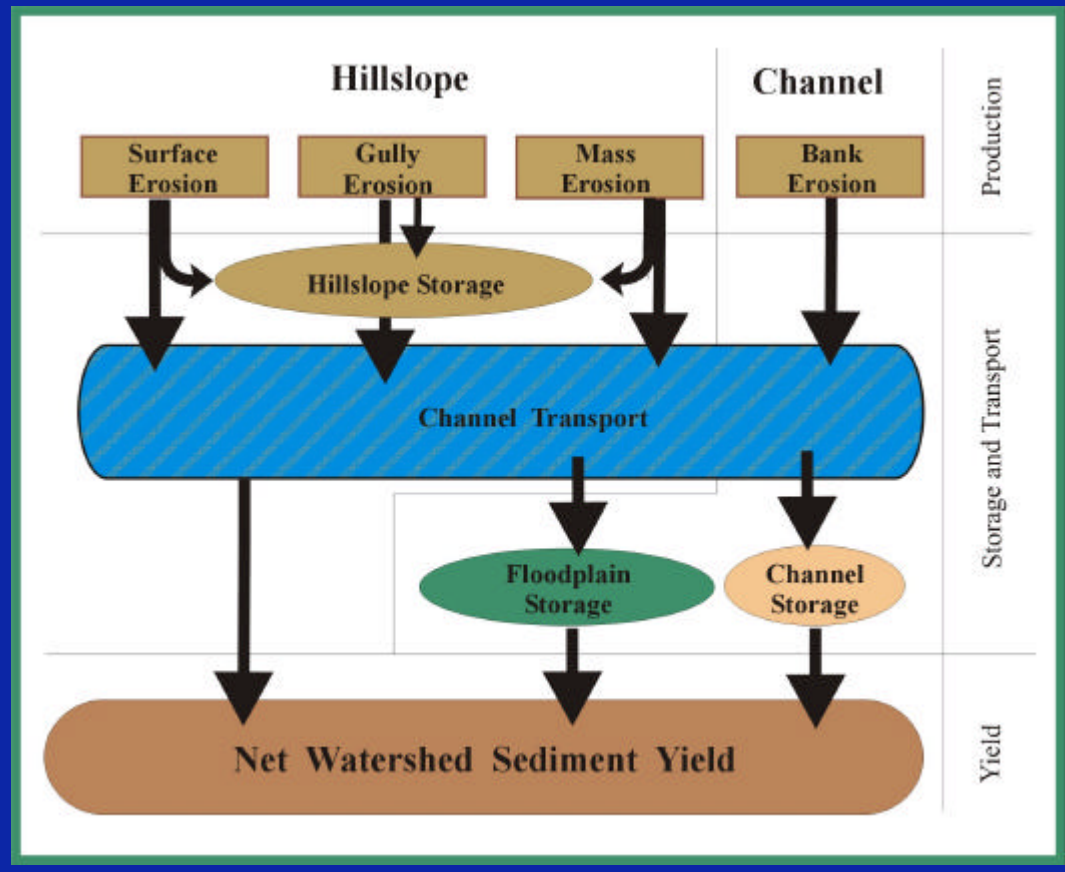
…to the Chesapeake Bay,

…to the Coastal Bays?

5. Gaps in our understanding / capabilities?

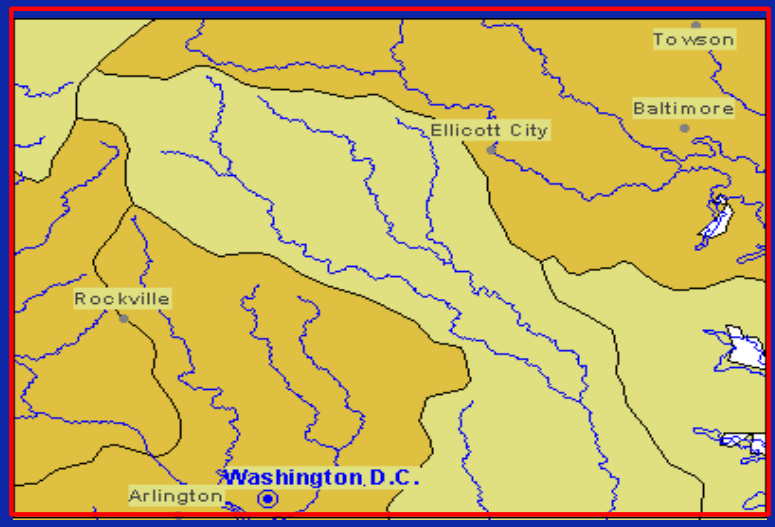
Sediment Movement (Flux) Information:

- Where?
- How Much?
- How Fast?
- How Often?
- What sizes?
- With what effect?



Where can we start?
Reservoir Watersheds

- Semi-closed sediment system
- Long term gage data
- Discrete land cover units



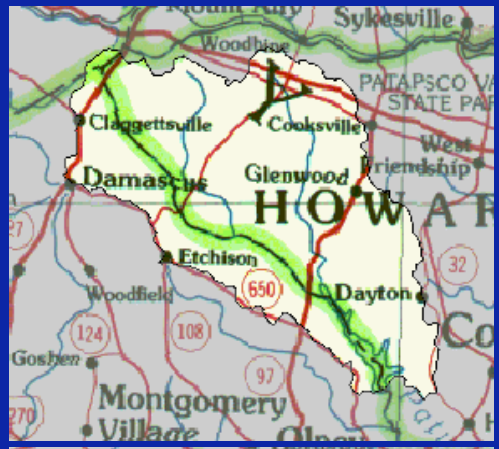
Upper Patuxent River

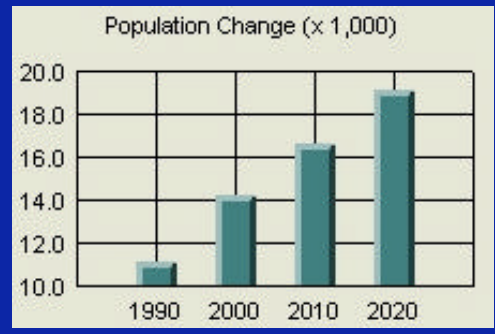
Watershed Restoration Division
Chesapeake and Coastal Watershed Services

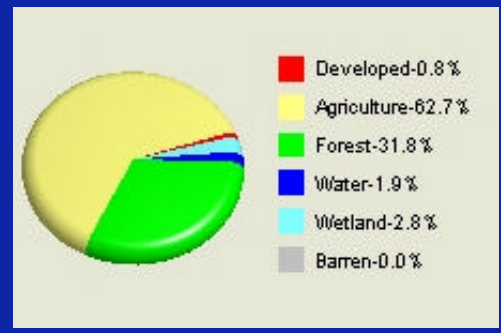
Piedmont Physiographic Region

Washington / Baltimore Corridor

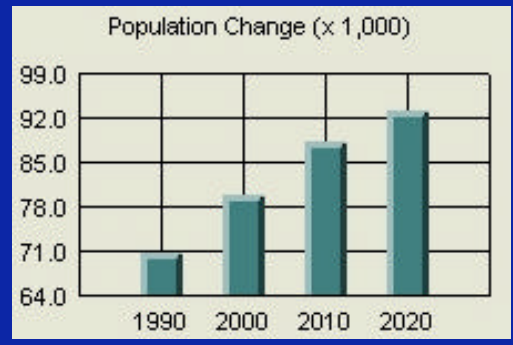
Upper Patuxent River

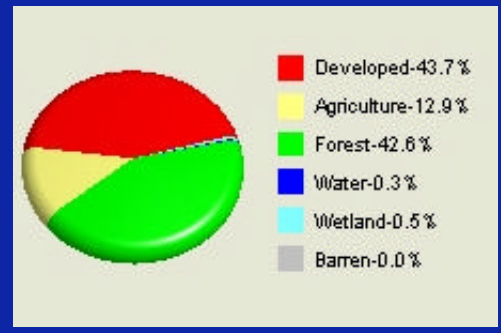






Cabin John Creek

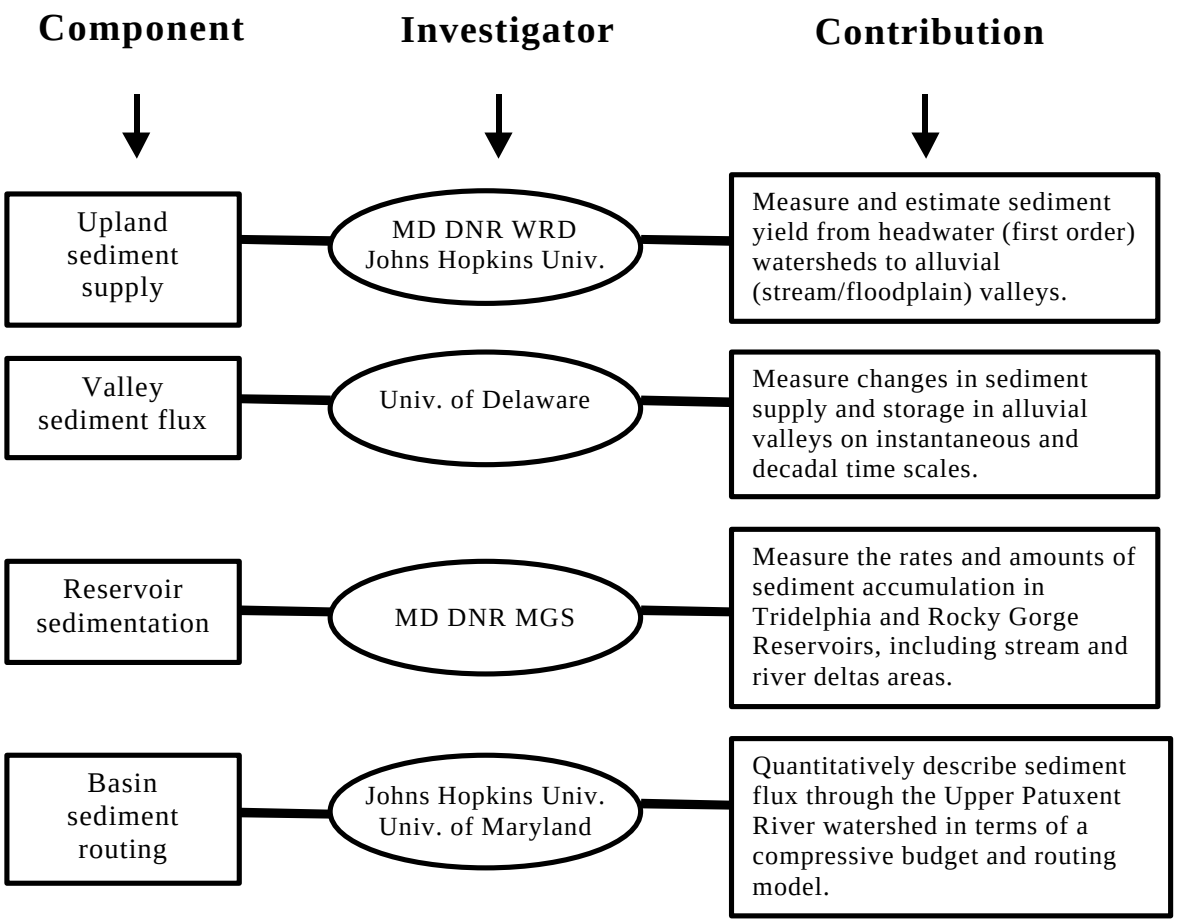




Source: EPA Chesapeake Bay Program
http://www.chesapeakebay.net (see watershed profiles)

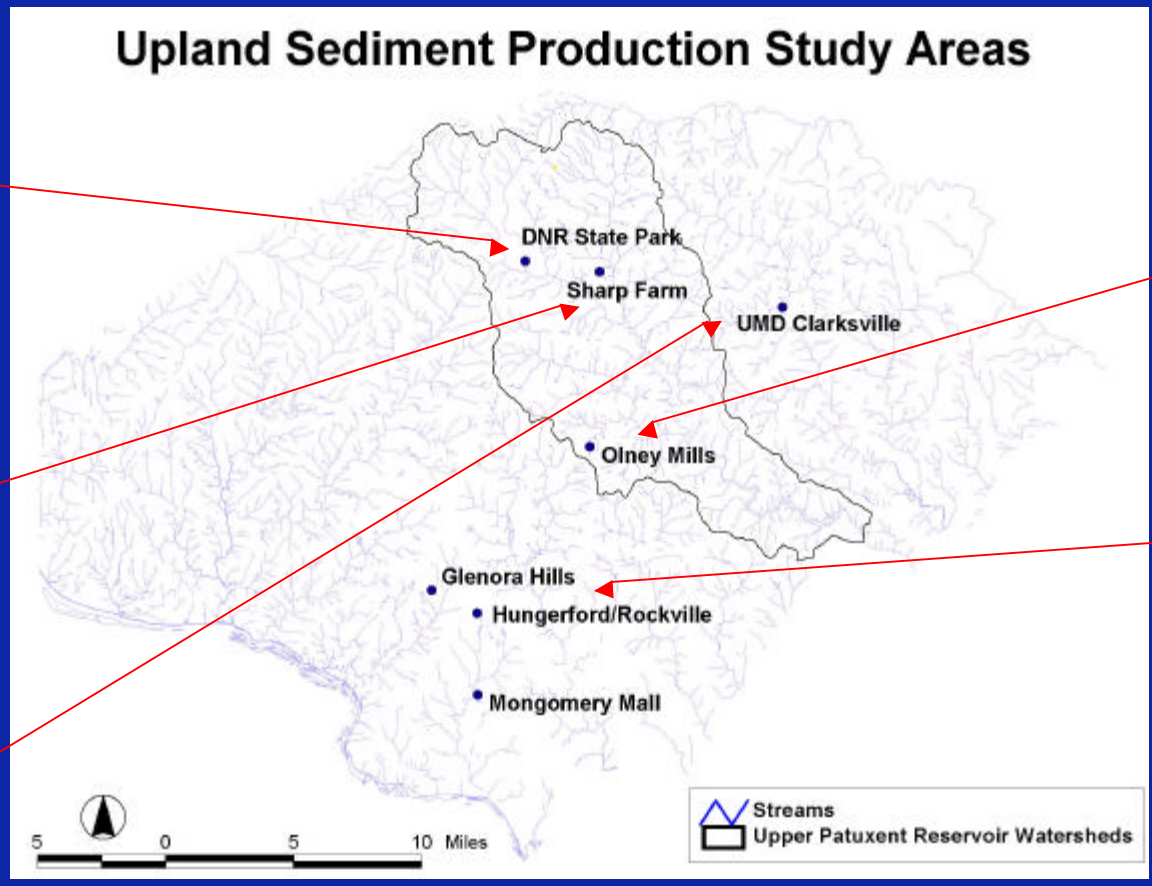
Chesapeake and Coastal Watershed Services
Watershed Restoration Division

Upper Patuxent River Sediment Budget Project Matrix



Upland Sediment Supply

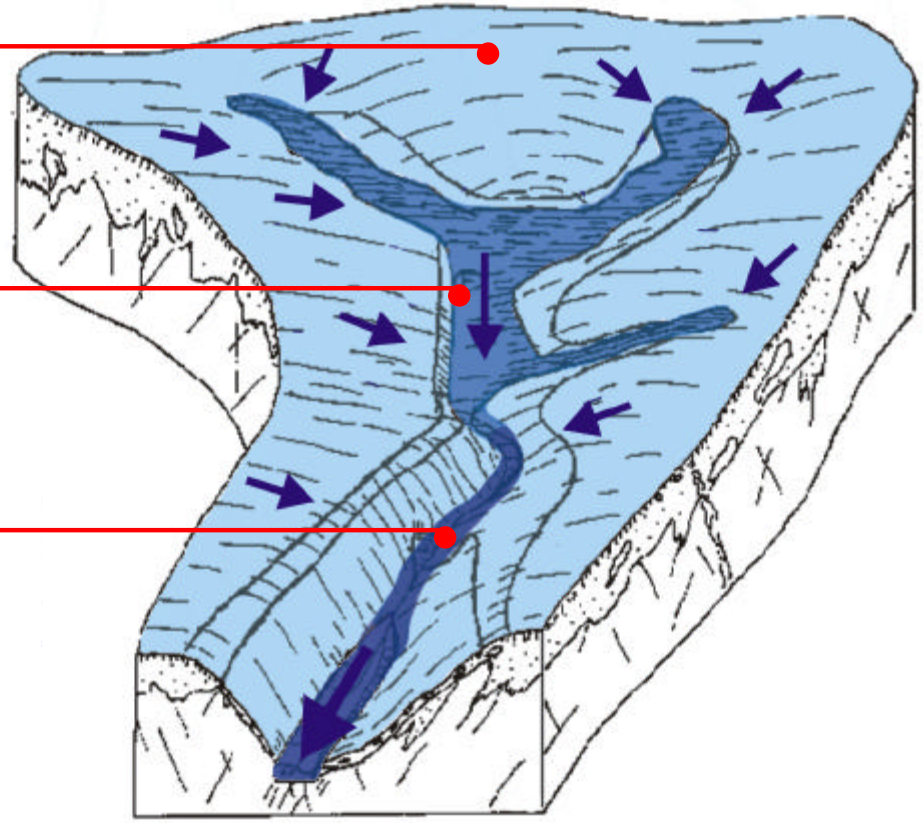
Five Piedmont Land Use Settings



Chesapeake and Coastal Watershed Services
Watershed Restoration Division

Upland Sediment Supply

- **Hillslope erosion**
  Overland (sheet) flow
- **Hillslope sediment routing**
  Shallow concentrated flow
- **First order channel erosion / storage**
  Channel flow

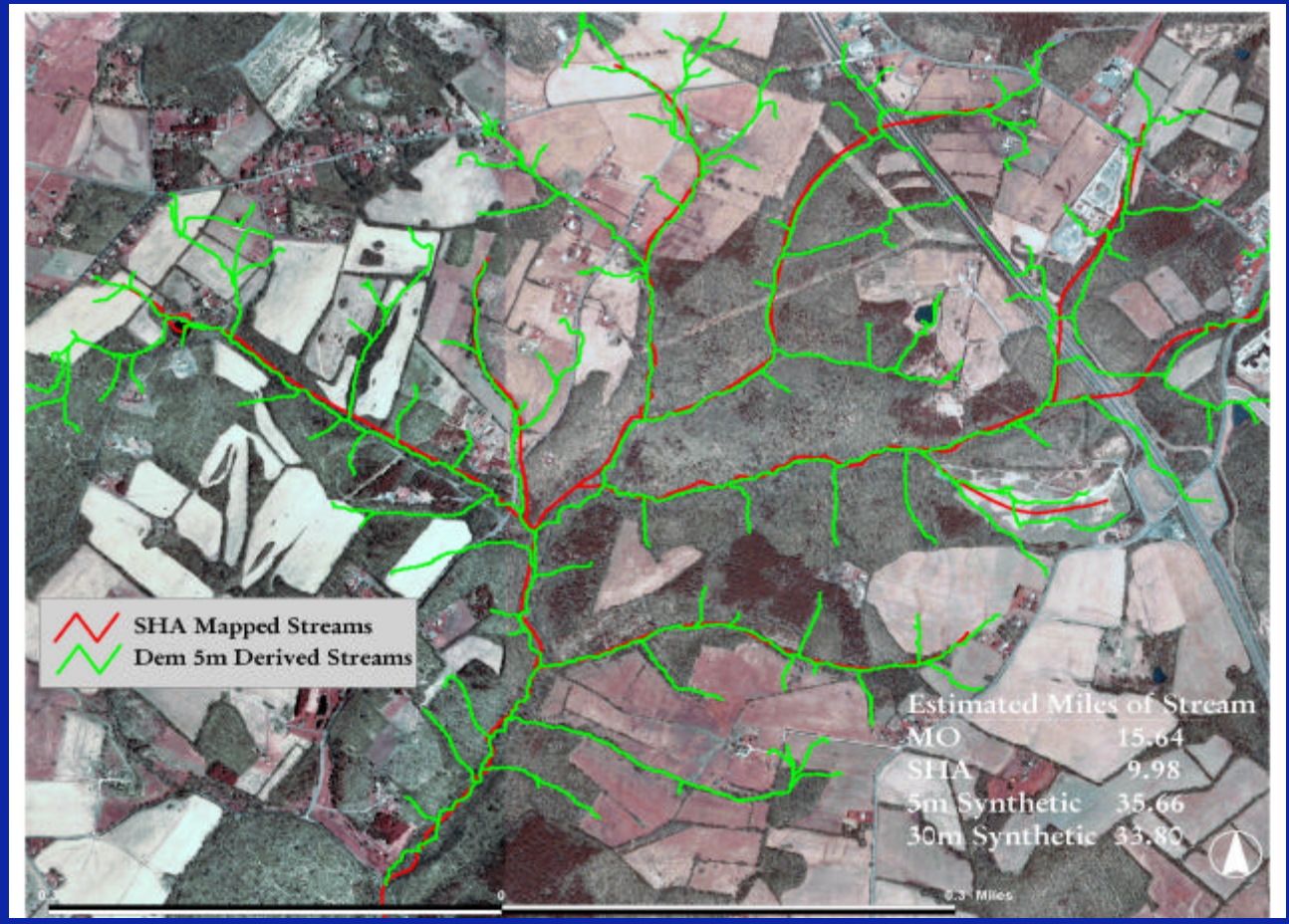


Storm flow sampling
- Water flow
- Sediment transport

Historic sedimentation record evaluations

Drainage Network Mapping

Identification of actual first order channel lengths for sediment source and storage analyses



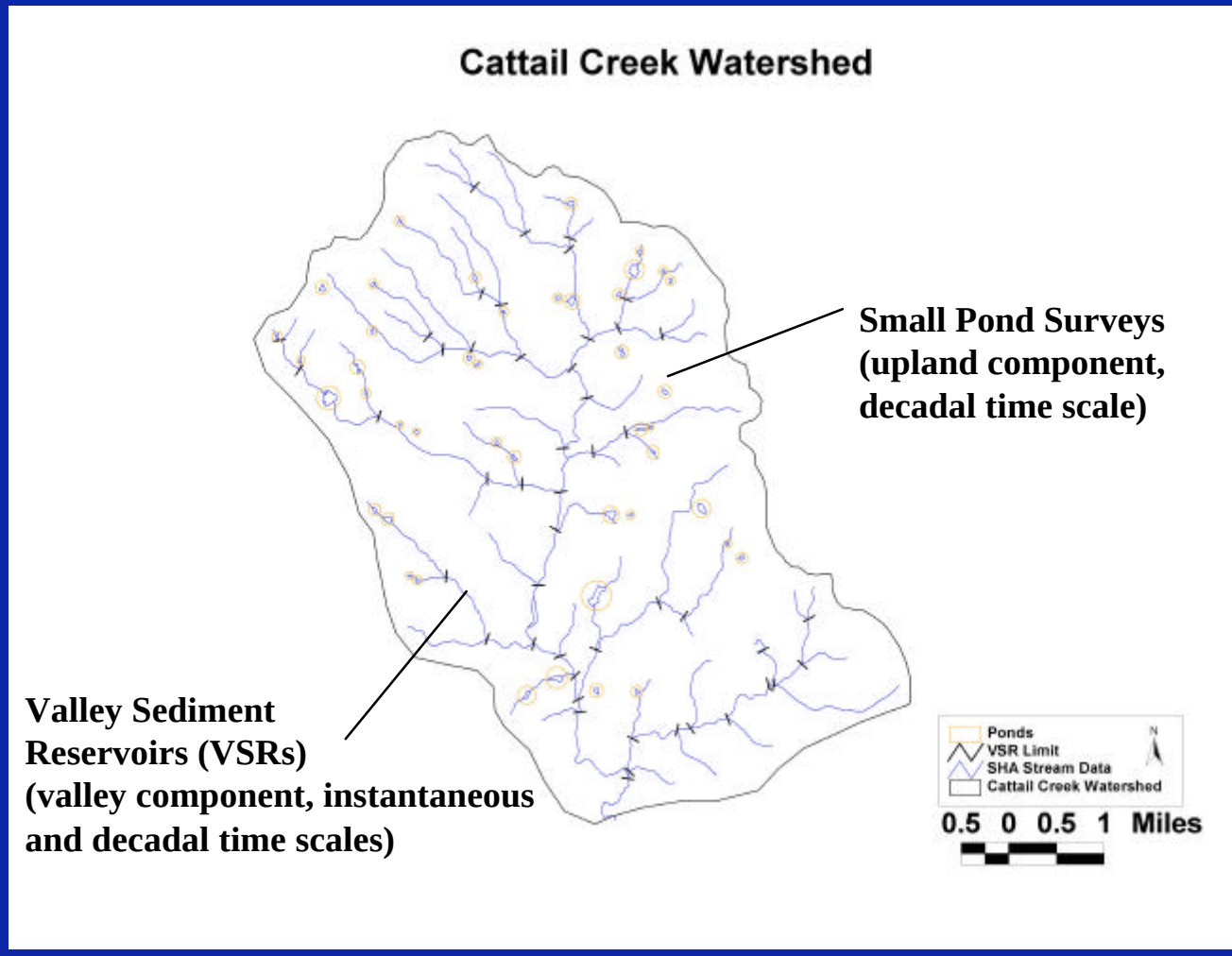
Ten Mile Creek
Source: Watershed Restoration Division, Maryland DNR
Orthophoto available on http://www.mdmerlin.net

Watershed Restoration Division
Chesapeake and Coastal Watershed Services

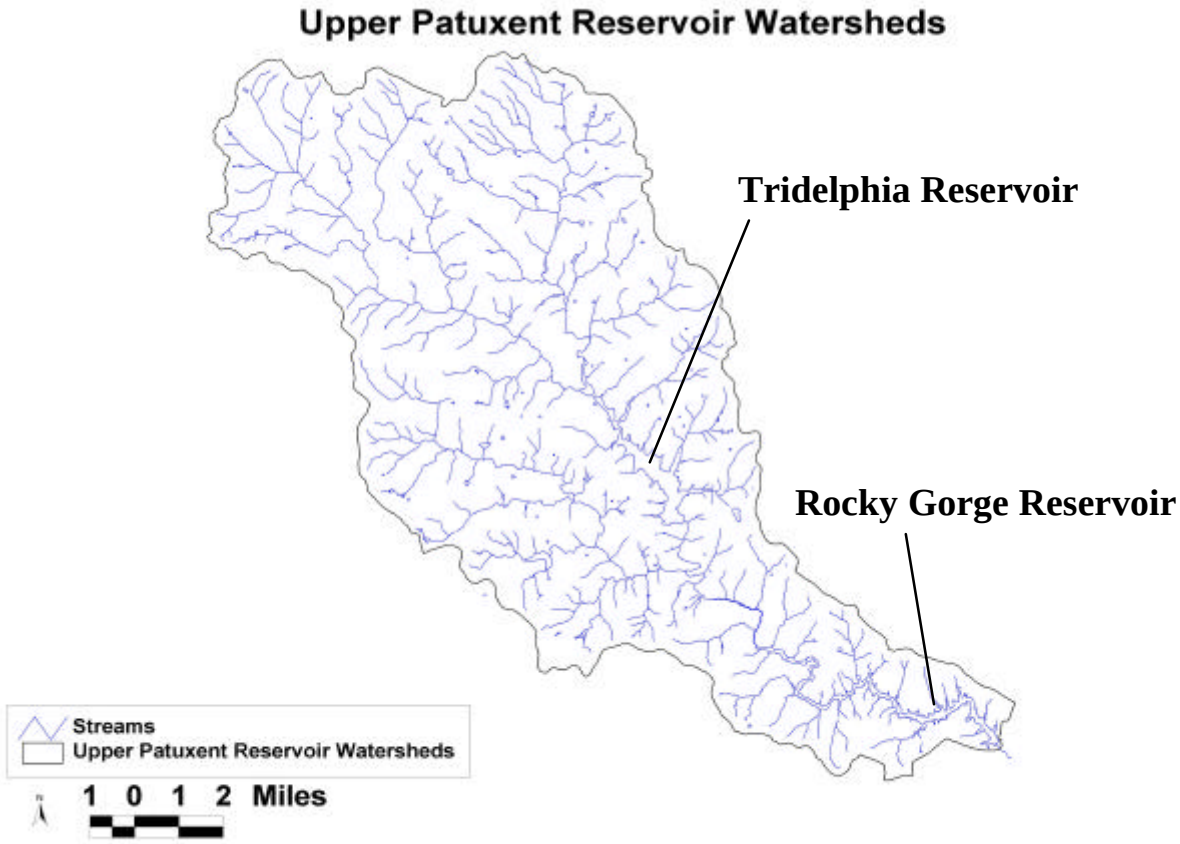
Valley Sediment Flux

Sediment sources and storage in alluvial valleys

Cattail Creek Watershed draining to the Patuxent River
Source: Watershed Restoration Division, Maryland DNR



Sediment Delivery



Reservoir surveys

Sediment routing model

Sediment budget

Source: Map by Watershed Restoration Division, Maryland DNR

Sediment Budget Benefits

Short Term:

- Erosion rates from single land use watersheds in the Piedmont
- Sediment yield rates to reservoirs
- Landscape diagnostics (process zones, sensitivity indices, etc.) for the Piedmont
- Transferable watershed-based approach for sediment budgeting

Sediment Budget Benefits

Intermediate Term:

- Improved evaluations of BMP effectiveness on a watershed scale
- Indicators of landscape sensitivity to “growth”
- Improved Bay model performance
- Better links between sediment sources and sinks
- Better links between sediment and biota

Sediment Budget Benefits

Long Term:

- Optimization of Watershed Management and Restoration Efforts
- Improved cost efficiency for Chesapeake Bay management and restoration programs

4 Sediment Questions that Need Answers

1. How can we effectively manage sediment in the Chesapeake Bay watershed?
2. Where & how is it most cost effective to implement sediment BMPs and related stream restoration efforts?
3. How can sediment load reductions be accurately credited to BMP implementation efforts?
4. How do we know Smart Growth is “smart” relative to sediment yields to the Bay?

Where does this leave us?

Good news: Sediment business is not new and we have gathered some information.

- Data exists for some types of sediment flux in large rivers and some areas of the Bay;
- We have some knowledge of long term sediment flux trends in the Bay estuary; and
- Good spatial data is becoming available.

Where does this leave us?

Bad news: We have very limited ability to forecast / predict sediment flux responses.

- More ***sediment data is needed***, particularly in small watersheds and specific settings;
- Representative ***bedload data is needed*** from small streams in different settings;
- ***Linkages*** between the components of watershed *sediment flux* (i.e., sources, sinks, etc.) need to be developed.

We’ve got work to do!

Chesapeake and Coastal Watershed Services
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